Prediction of Rotorcraft Pitch-Link Loads

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The pitch links of rotor blades are essential hardware that provide direct control to rotorcraft. The pitch-link loads undergo large changes in magnitude as a result of flight conditions that range from those of relatively benign level flight to those associated with severe, complex maneuvers. In the present study, a "complex" maneuver was defined as one that involved simultaneous non-zero aircraft angle of bank (associated with turns) and aircraft pitch rate (associated with a pull-up or a push-over). Also, since a typical rotor blade pitch link operates in a highly dynamic environment, the pitch-link loads obtained from flight tests have associated with them a greater degree of uncertainty. Analytical prediction of pitch-link loads is thus difficult, and methods that provide accurate results are highly desirable. The objectives were (1) to obtain physical insights into the nature of complex maneuvers and (2) to apply neural networks to efficiently characterize maneuver-related rotorcraft blade pitch-link loads. The NASA/Army UH-60A Airloads Program database was used.

Since existing load factors do not represent the above-defined complex maneuvers, a new physics-based parameter, the maneuver-load-factor (MLF) was derived and used. The MLF includes both the aircraft angle of bank and pitch rate, resulting in a single parameter. Figure 1 shows the MLF and the pitch-link loads variations with forward speed. Approximately 80 test data points (with pitch-link loads greater than 1,000 pounds) were considered. The associated neural network application involved five inputs, namely, the MLF and four standard parameters. The neural network output was the peak oscillatory pitch-link load. Figure 2 shows the presently obtained finer correlation (±400 pounds error-band). This correlation was obtained using a single-hidden-layer, back-propagation neural network with 10 processing elements; it was trained for 600,000 iterations and had a final root-mean-square error of 0.07.

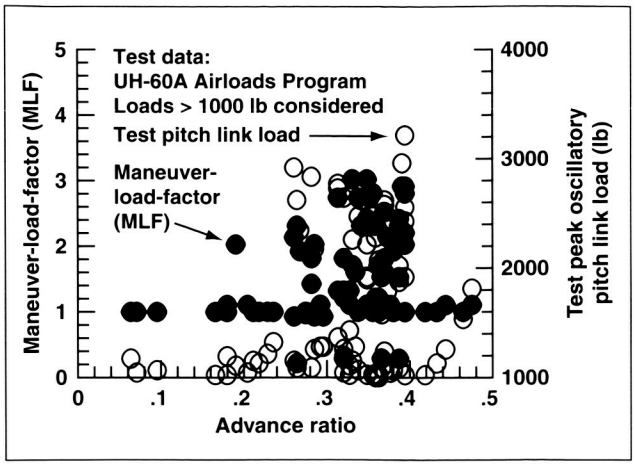

Fig. 1. Maneuver-load-factor and pitch-link load variations with speed (advance ratio).

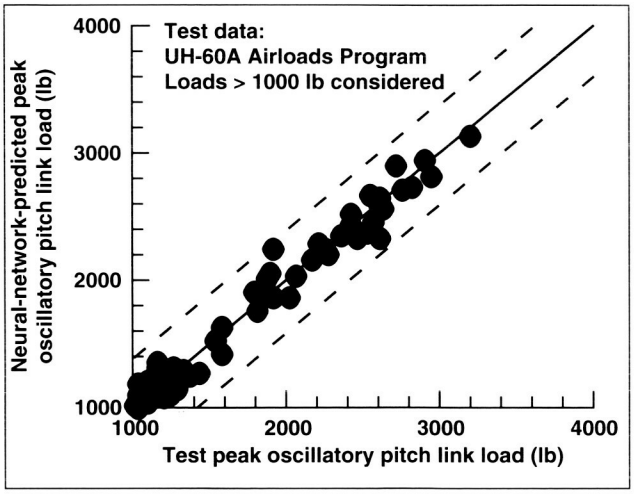

Fig. 2. Pitch-link load correlation using physics- and neural-network-based approach.

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